

LOAN DOCUMENT

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<p><i>Loss Radar Architecture</i> <i>multi-Operative v. Single aperture</i></p> <p>DOCUMENT IDENTIFICATION 2000</p>		
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Laser Radar Architecture: Multi-Aperture vs. Single Aperture

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Introduction

- Free space optical communication and laser radar links that operate within even a thin atmosphere can exhibit severe temporal short-term fading and cause tracking difficulties that are attributed to turbulence-induced scintillation
- Various system architectures can be developed to mitigate scintillation and other atmospheric effects
 - < Increased transmitter power (may not be practical)
 - < Increased aperture size (may not be practical)
 - < Multiple small apertures at the receiver (both direct and coherent detection)

Array Receivers: Direct Detection

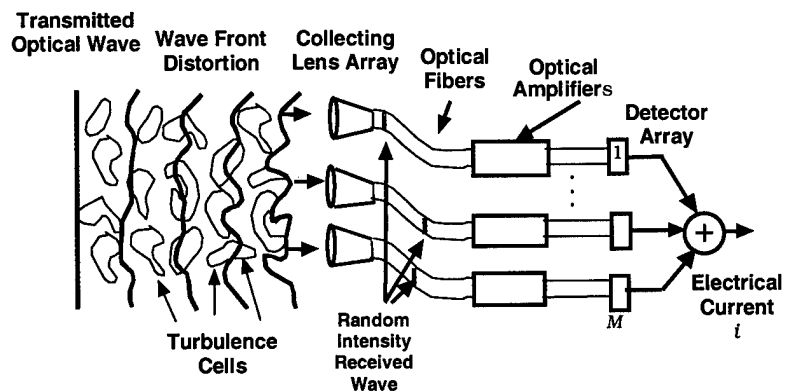


Figure 1 Array of M direct detection receivers.

Array Receivers: Direct Detection SNR

- Let the summed output of M statistically independent detectors be described by

$$i \ni \sum_{j=1}^M (i_{Sj} \oplus i_{Nj}), \quad (1)$$

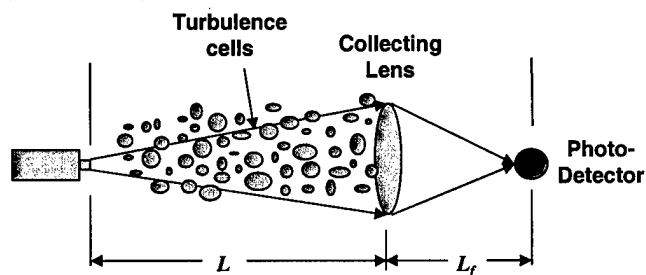
- < each i_S is a random signal and each i_N is a zero-mean noise current
- < we assume the mean and variance of each signal and noise current is identical

- It follows therefore that the *mean rms amplitude SNR* is simply

$$\langle \text{SNR}_M \rangle \ni \frac{M \langle i_{S,1} \rangle}{\sqrt{M} \sigma_{N,1}} \ni \sqrt{M} \langle \text{SNR}_1 \rangle, \quad (2)$$

where $\langle \text{SNR}_1 \rangle$ is the mean SNR of a single detector.

Direct Detection: Aperture Averaging



- The reduction in scintillation with increasing telescope collecting diameter D , called *aperture averaging*, can be deduced from the normalized power fluctuations P over the area of the collecting aperture lens, i.e.,

$$\sigma_I^2(D) \propto \frac{\langle P^2 \rangle - \langle P \rangle^2}{\langle P \rangle^2}$$

Array Receivers: Direct Detection

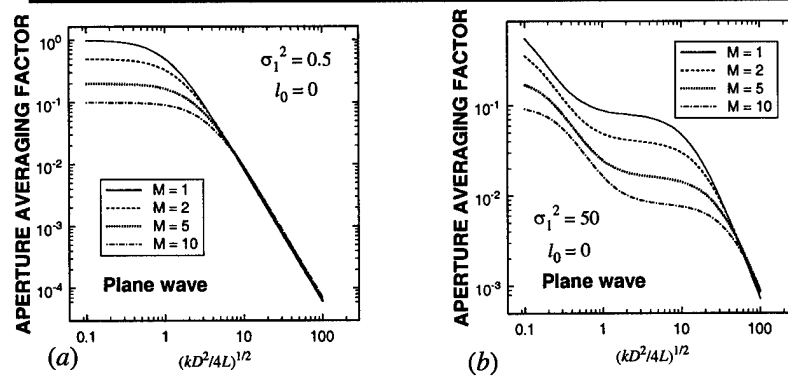


Figure 2 Predicted aperture averaging factor in (a) *weak irradiance fluctuations* and (b) *strong fluctuations*. ($\sigma_1^2 = 1.23C_n^2 k^{7/6} L^{11/6}$)

NOTE: The glass area of the M collecting lenses is the same as that of the single large lens and inner scale $l_0 = 0$.

Array Receivers: Coherent Detection

Three common multiple-receiver architectures are the following:

- **Selection combining**
 - < signal from receiver with largest SNR is switched to output (all others discarded)
 - < simplest architecture but does little to improve SNR
- **Maximal-ratio (MR) combining**
 - < RF signals are co-phased, have their amplitudes adjusted, and adjusted signals summed to generate composite signal
 - < considered optimal design but requires major effort in instrumentation to achieve proper weighting factors
- **Equal-gain (EG) combining**
 - < equal gains are applied to all RF signals
 - < only the phase is adjusted to match signal field
 - < performance close to that of MR receiver

Array Receivers: Coherent Detection SNR

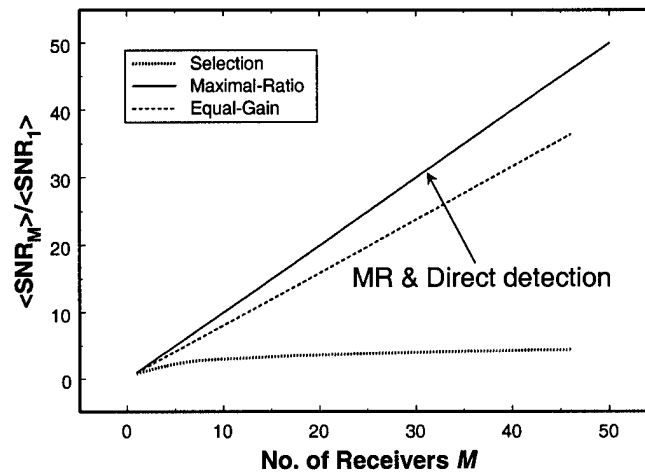
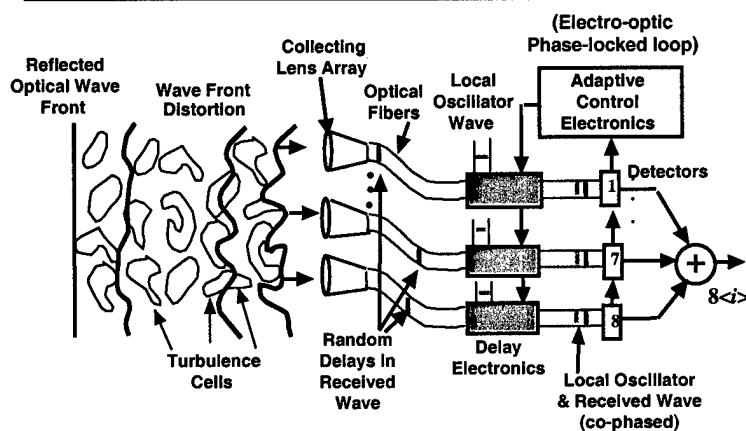
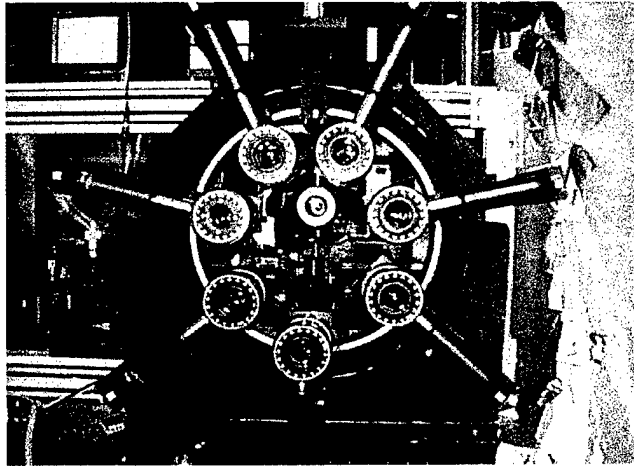


Diagram of EG Coherent Array Receiver



EG Coherent Array Receiver





ISTEF Site

**(BMDO Innovative Science and
Technology Experimentation Facility)**



- ISTEf brings together electro-optics, sensors, and lasers developed for experiments observing launches, etc. at KSC
- ISTEf site at sea level with 1 km and 12.5 km ranges
- ISTEf operated by Nichols Research

ISTEF Experiment: EG Coherent Array

